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Kevin Delin

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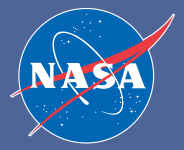

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PARTICIPANTS

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Sasha Tsapin
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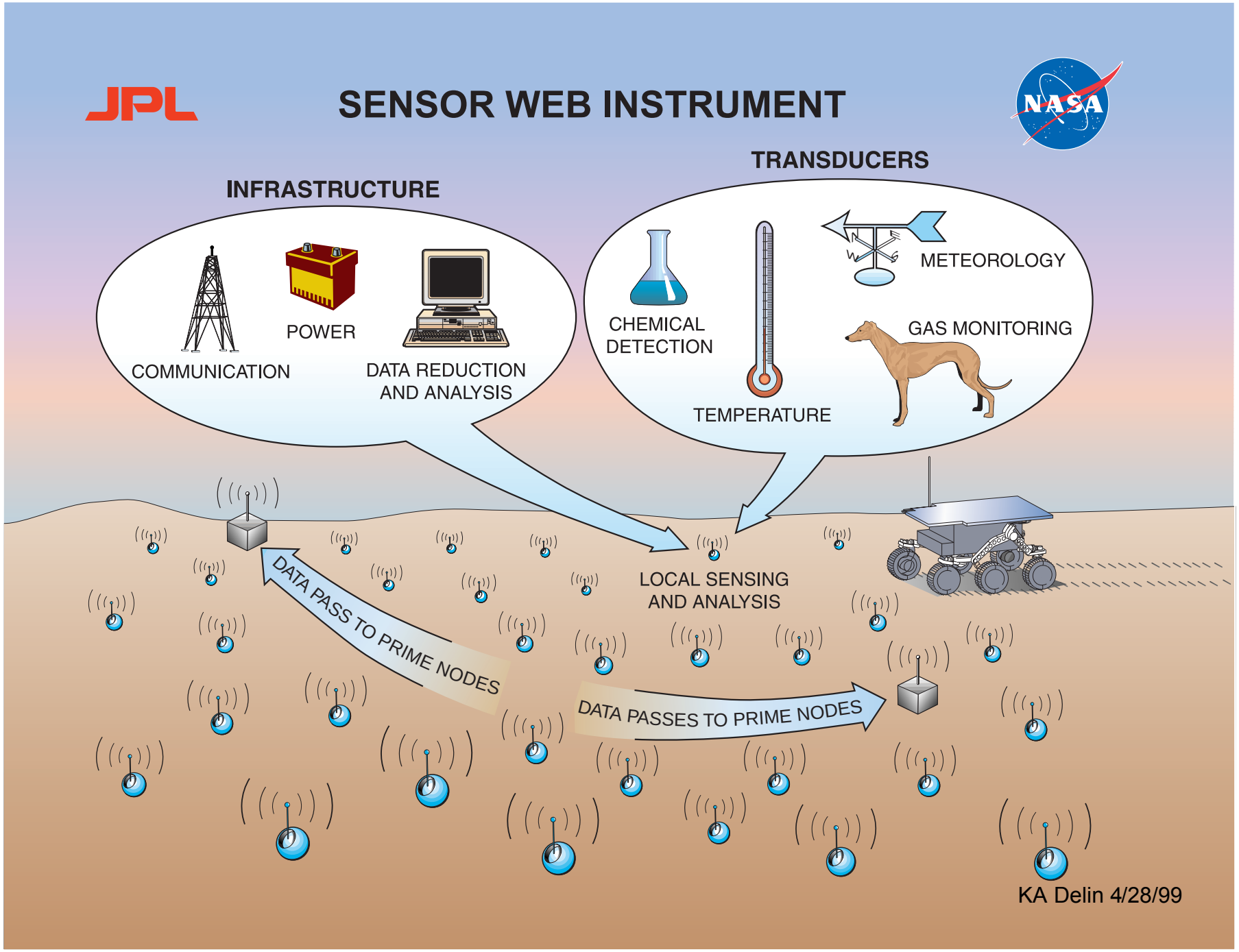
THE SENSOR WEB INSTRUMENT

A Sensor Web is a set of distributed transducers that cooperate to form a large macroinstrument capable of autonomous operation for *in situ* and remote sensing and environmental exploration. The interaction between nodes gives the macroinstrument an intelligence to react to its environment.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SENSOR WEB INSTRUMENT
NASA
INFRASTRUCTURE
TRANSDUCERS
COMMUNICATION
POWER
DATA REDUCTION AND ANALYSIS
CHEMICAL DETECTION
METEOROLOGY
GAS MONITORING
TEMPERATURE
LOCAL SENSING AND ANALYSIS
DATA PASS TO PRIME NODES
DATA PASSES TO PRIME NODES
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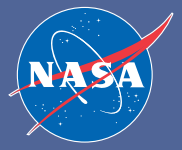

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SENSOR WEB FEATURES

- Flexible Concept (land/aqueous/atmosphere/space)
- Low Power/Lightweight
- Cheap/Economy of Scale
- Fault Tolerant /Built-in Redundancy
- Macroscopic Web Intelligence
- Scalable
- Long Life
- Simple Deployment

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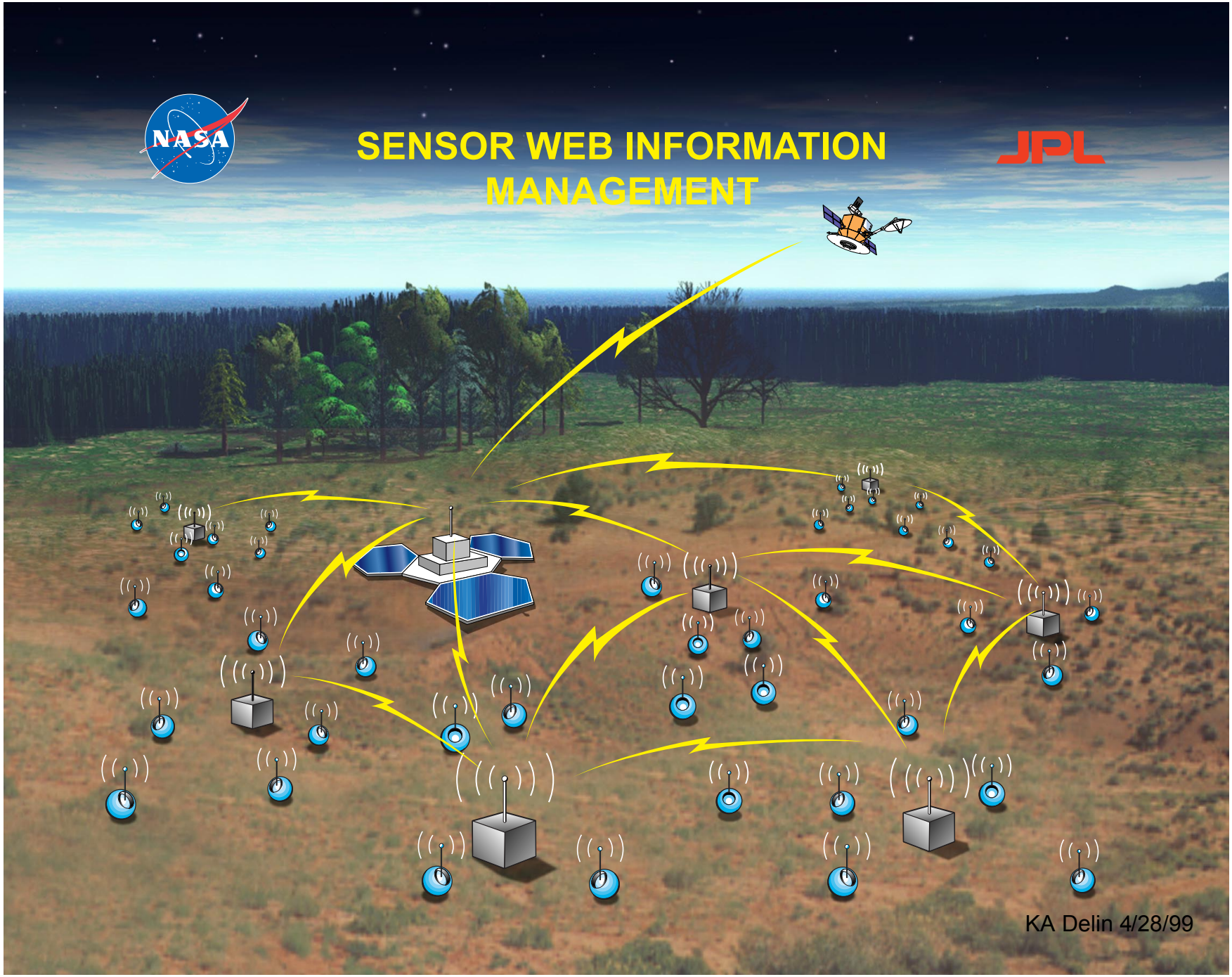
SENSOR WEB INFORMATION MANAGEMENT
NASA
JPL
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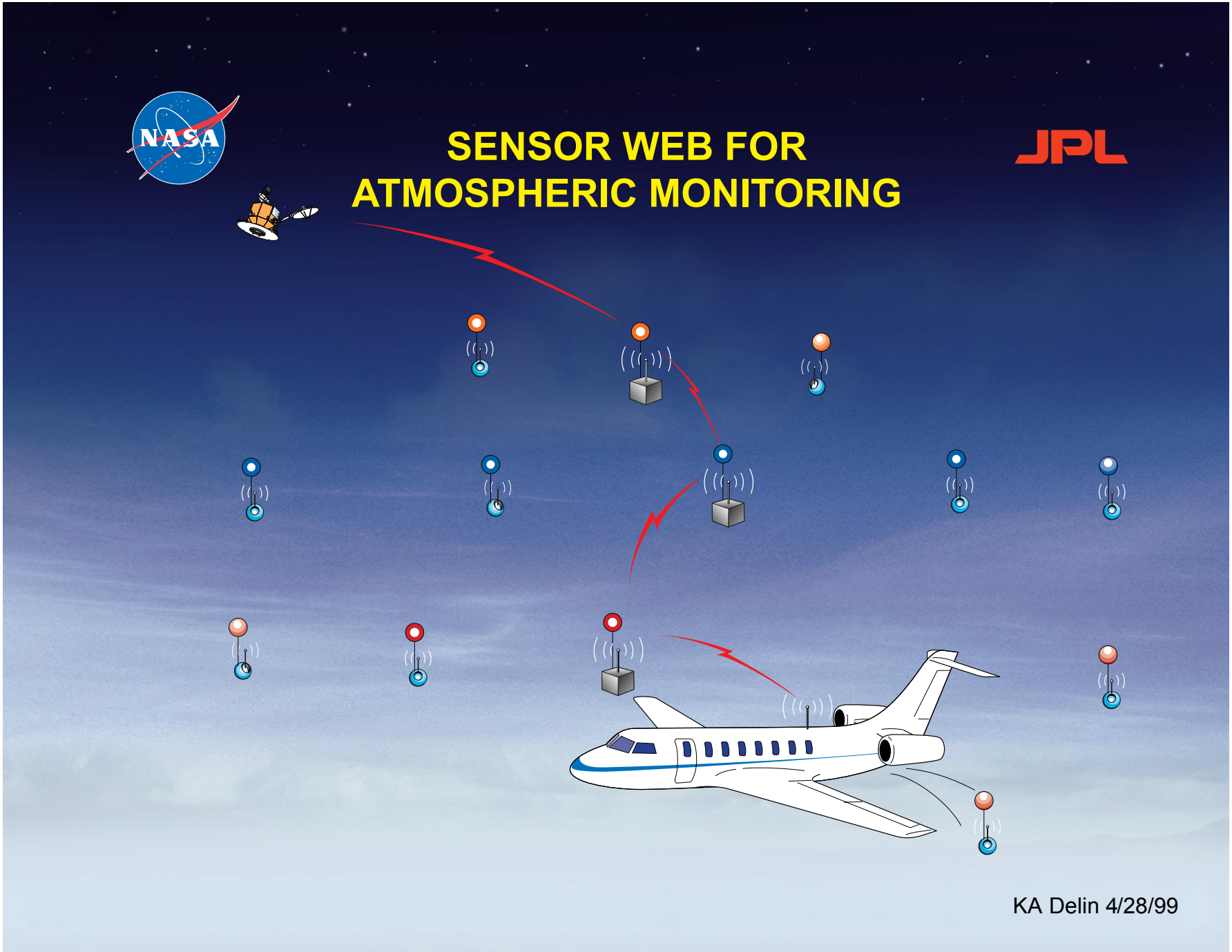
SENSOR WEB FOR ATMOSPHERIC MONITORING



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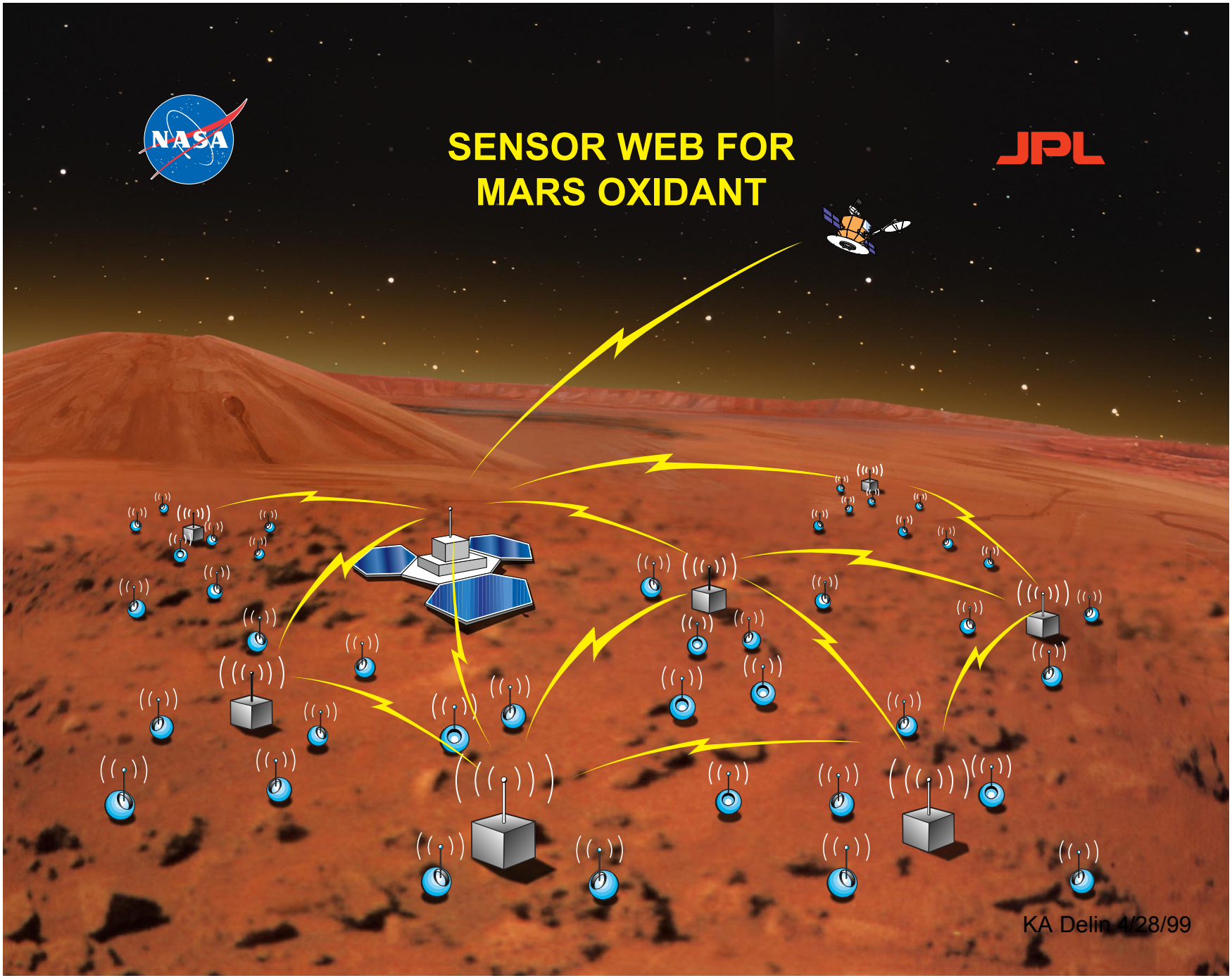
SENSOR WEB FOR
MARS OXIDANT
NASA
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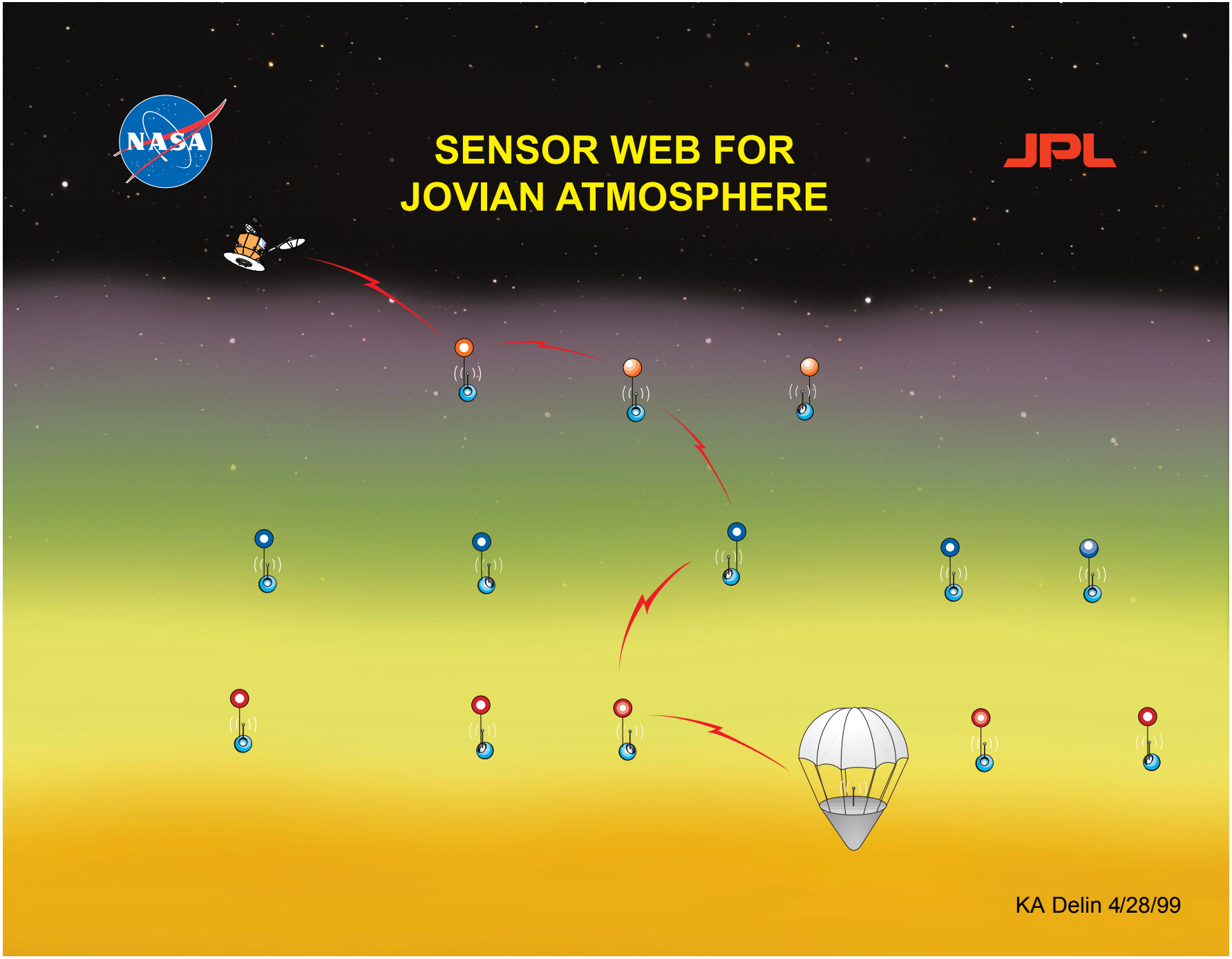
SENSOR WEB FOR JOVIAN ATMOSPHERE



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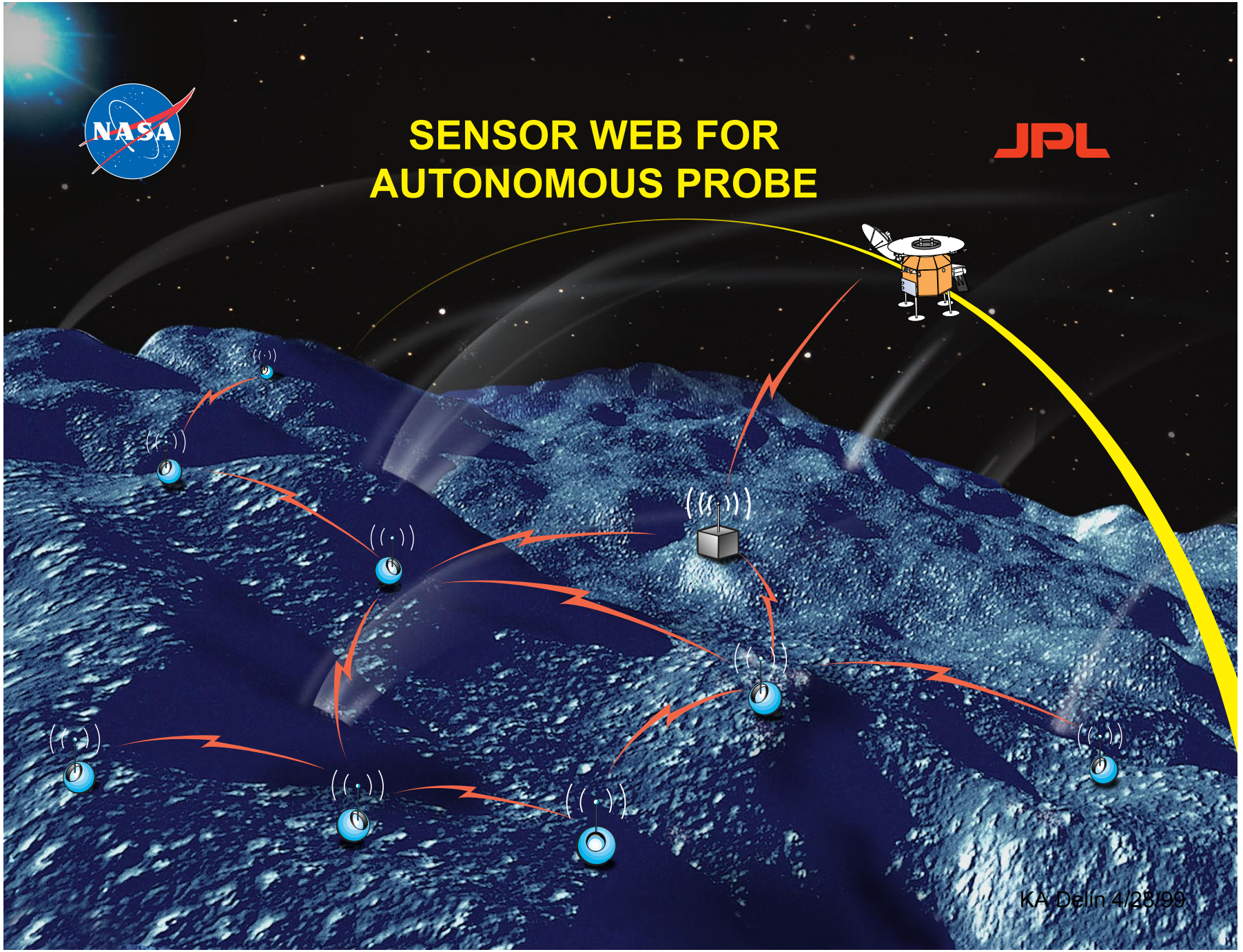
SENSOR WEB FOR
AUTONOMOUS PROBE
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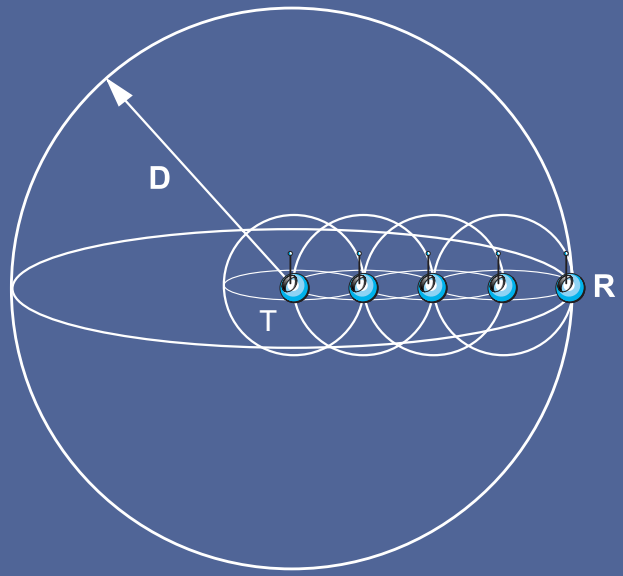
WHY MULTI-HOPPING IS EFFICIENT

FRIIS TRANSMISSION EQUATION: $P_{transmit} \propto r^m P_{receive} \quad (2 \le m \lesssim 4)$

$$\Rightarrow P_{transmit} \propto \frac{1}{N^{(m-1)}} D^m P_{receive}$$



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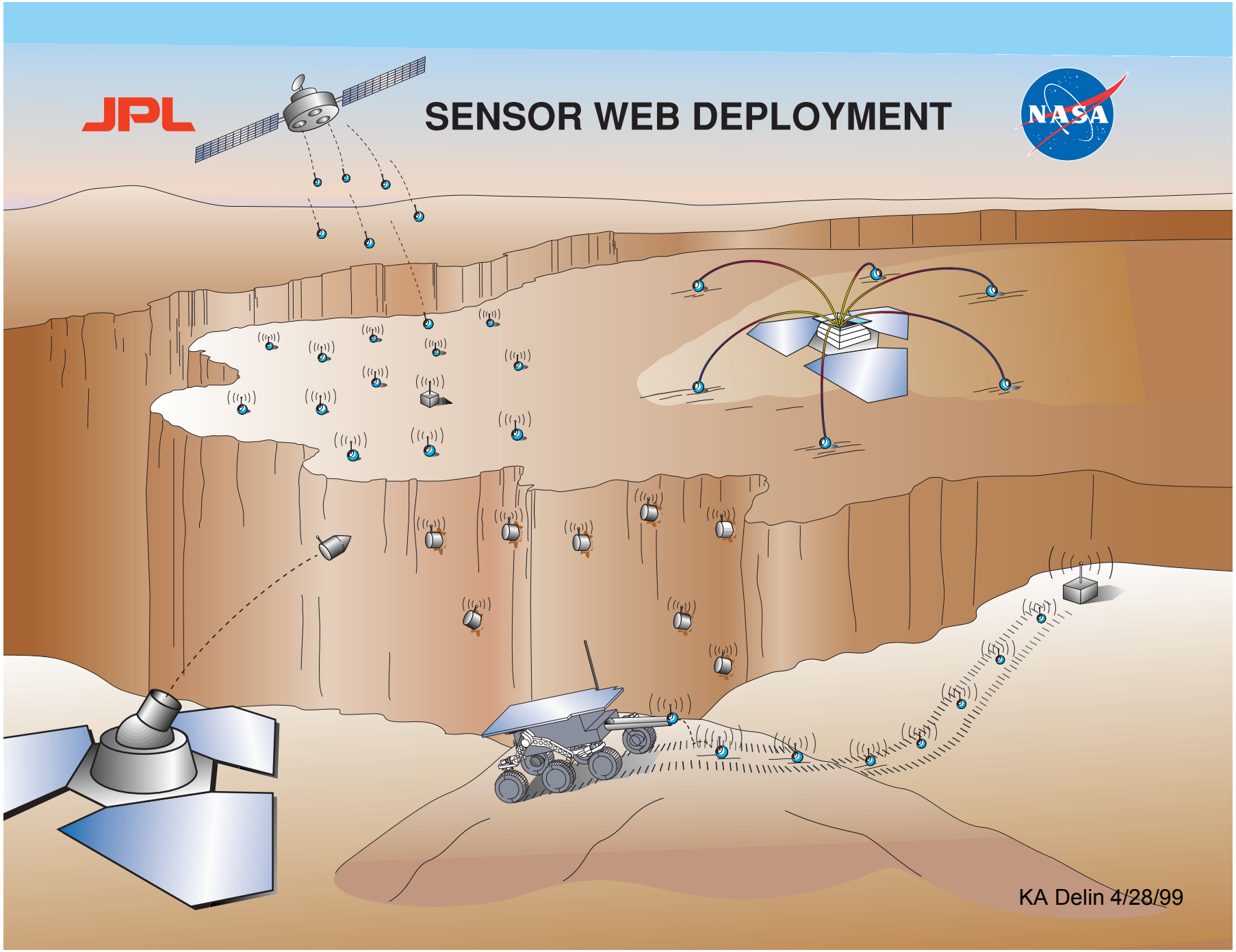
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SENSOR WEB DEPLOYMENT
NASA
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SENSOR WEB DEVELOPMENT APPROACH

- Focus on field-specific applications to gain experience with sensor web design and use (guerrilla instrument development)
- Focus on field tests that will yield specific scientific results
- Leverage emerging technologies to increase sensor web performance
- Develop appropriate packaging
- Develop deployment mechanisms

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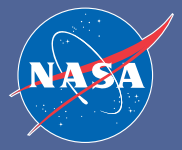

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EXTREMOPHILE ENVIRONMENTS

LOCATION	CONDITIONS	MINIMUM DISTANCE FROM JPL (miles)
MONO LAKE	WET, ALKALINE	300
HOT SPRINGS (EASTERN SIERRA)	WET, HOT, ACID	300
DEATH VALLEY	DRY, HOT	300
BAJA ALGAL MATS	WET, HOT, AEROBIC/ANAEROBIC	400
HYDROTHERMAL VENTS (PACIFIC RIM)	WET, HOT/COLD, ACID/ALKALINE	1500 – 5000
HONEYMOON LAKE	WET, COLD	2000
ANTARCTIC DESERT	DRY, COLD	8000
LAKE VOSTOK	WET, COLD	8500
MARS PERMAFROST	DRY, COLD	40,000,000
EUROPA	WET, COLD, HOT(?)	400,000,000

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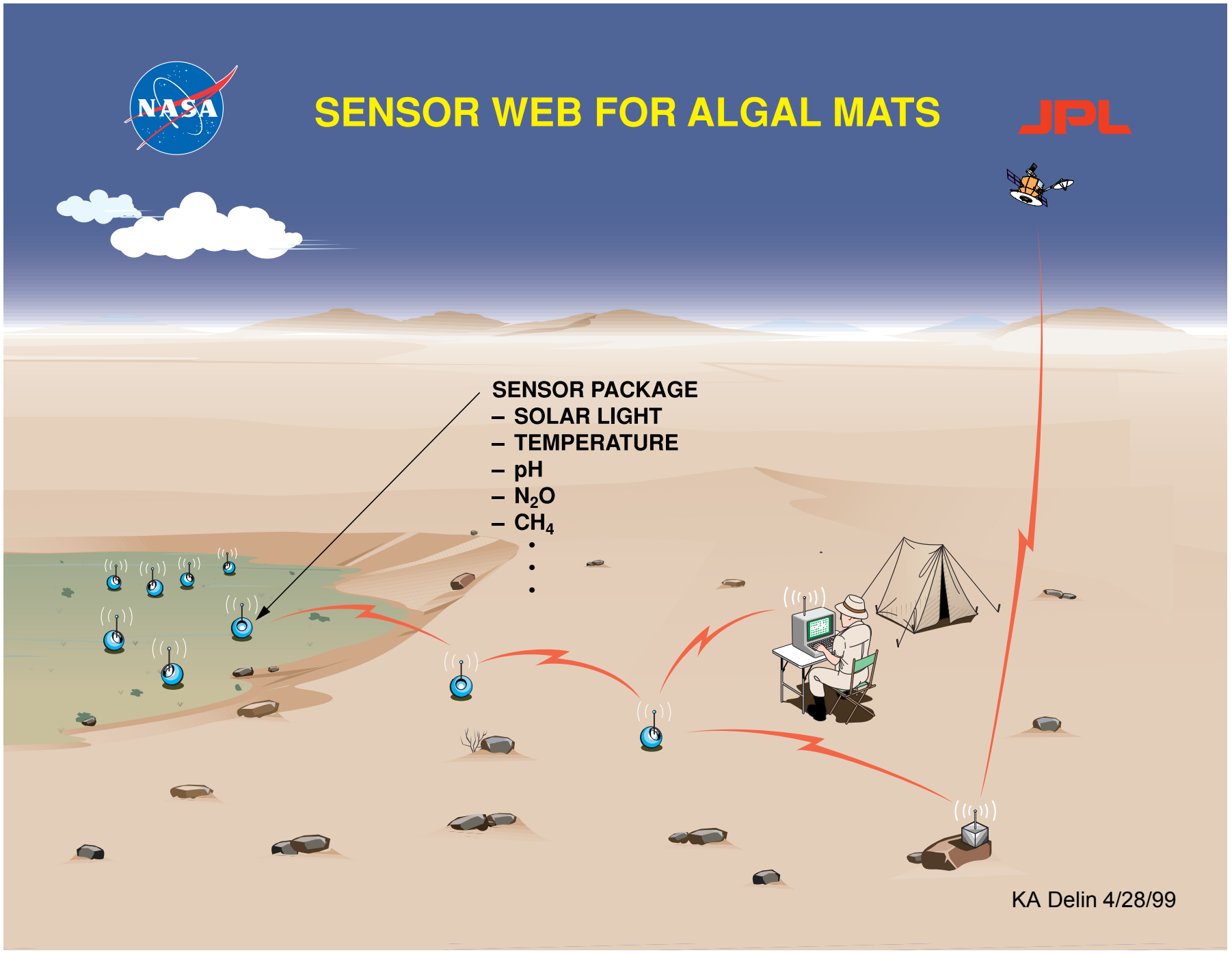
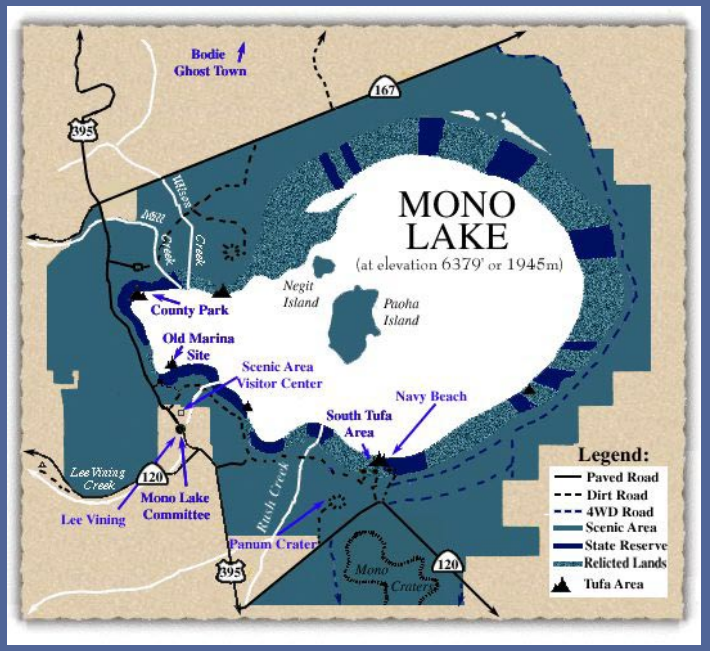
SENSOR WEB FOR ALGAL MATS



MONO LAKE, CALIFORNIA



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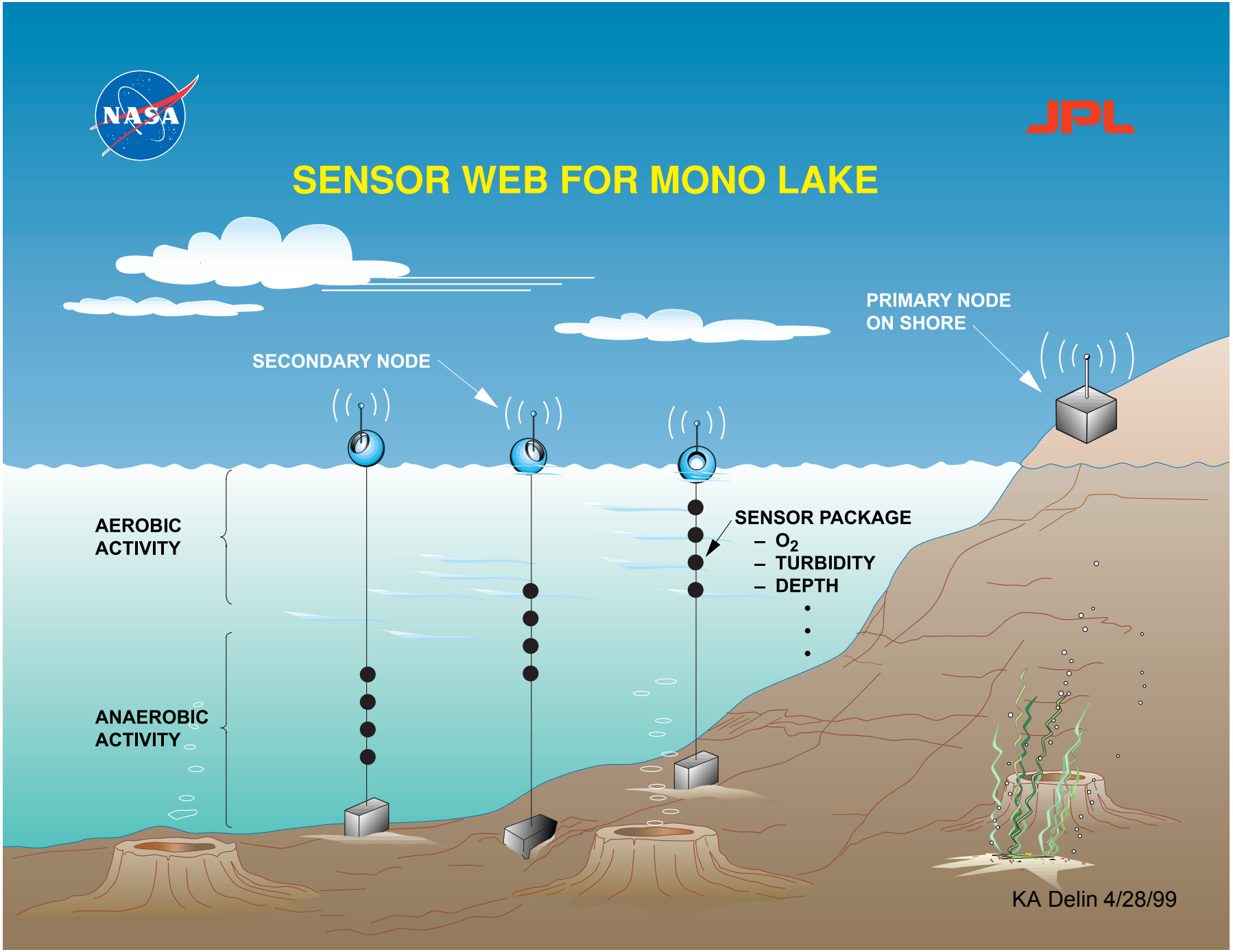
NASA
JPL
SENSOR WEB FOR MONO LAKE
PRIMARY NODE
ON SHORE
SECONDARY NODE
AEROBIC
ACTIVITY
ANAEROBIC
ACTIVITY
SENSOR PACKAGE
– O_2
– TURBIDITY
– DEPTH
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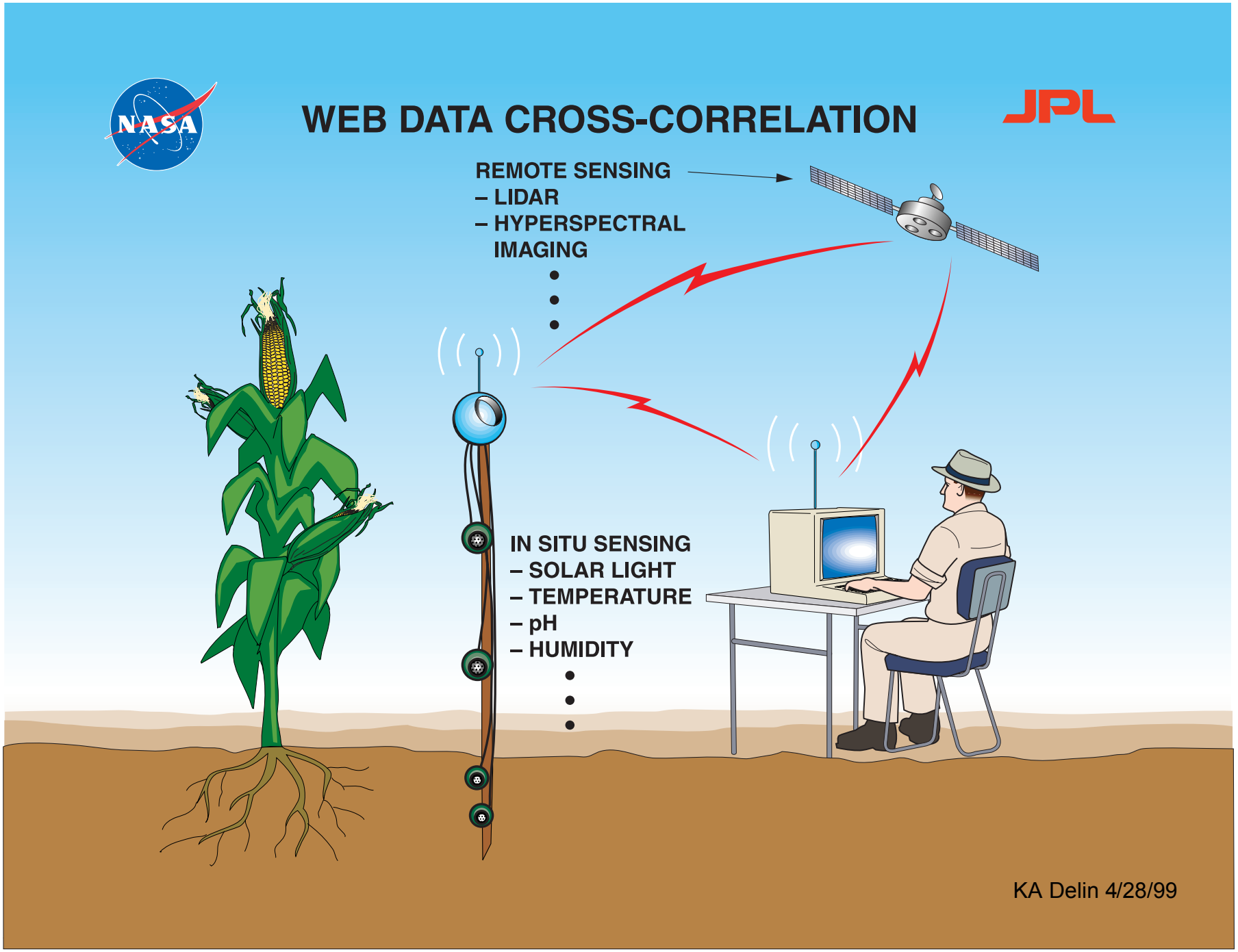
WEB DATA CROSS-CORRELATION



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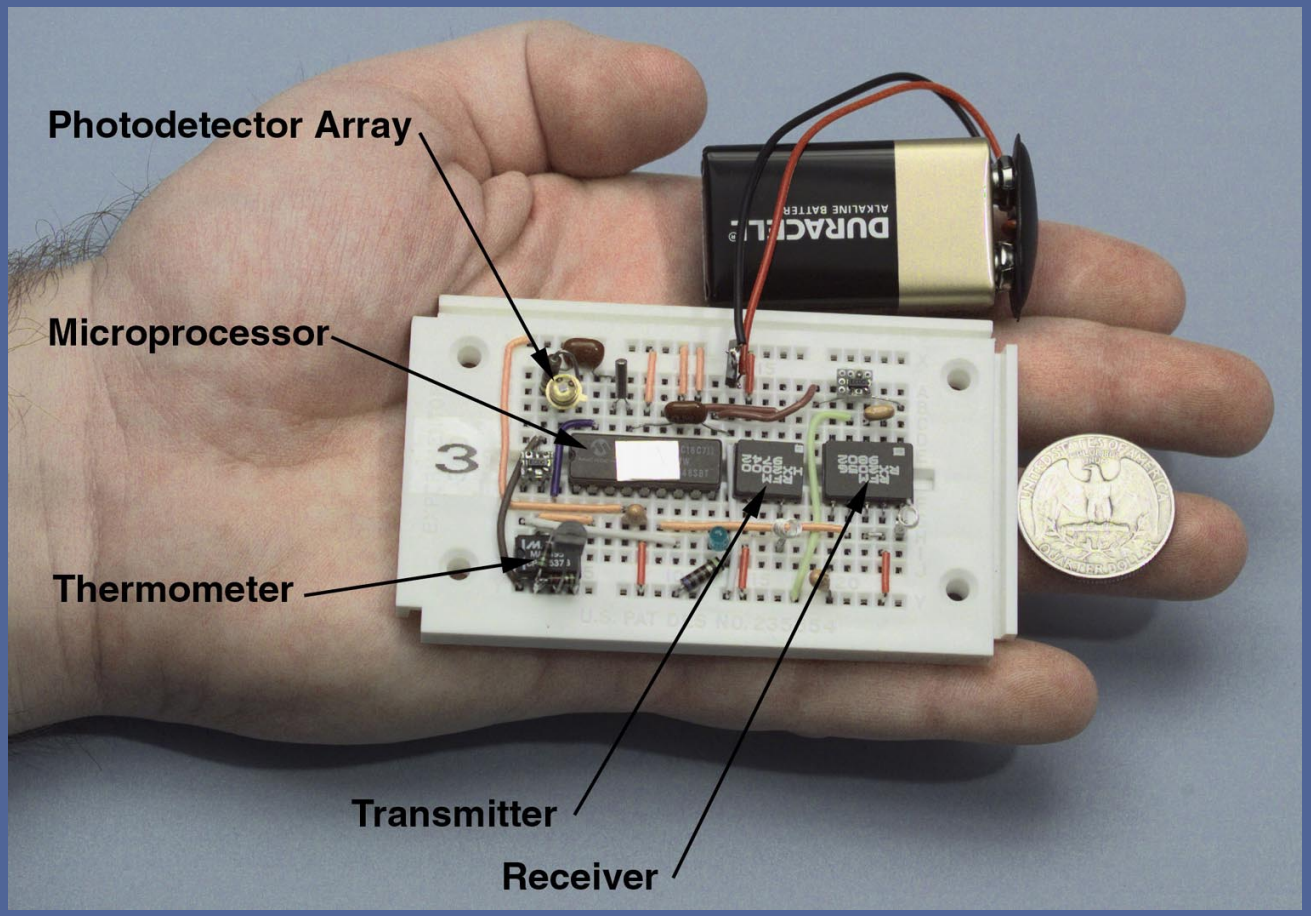
$50 WORTH OF COMMERCIAL PARTS



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SENSOR WEB POD PROTOTYPE

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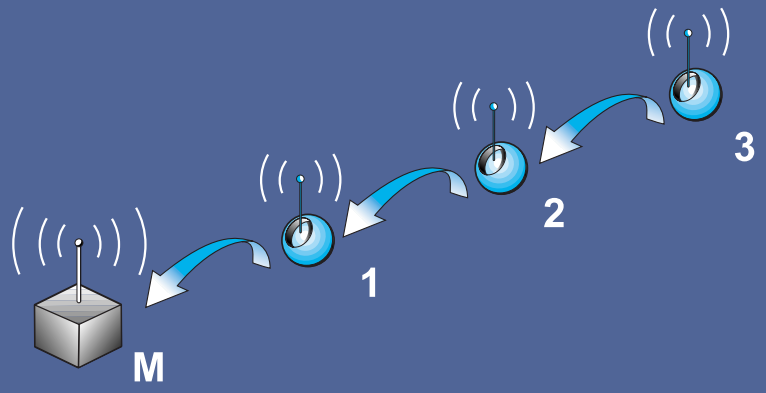
SENSOR WEB PERFORMANCE DEMONSTRATED AT JPL

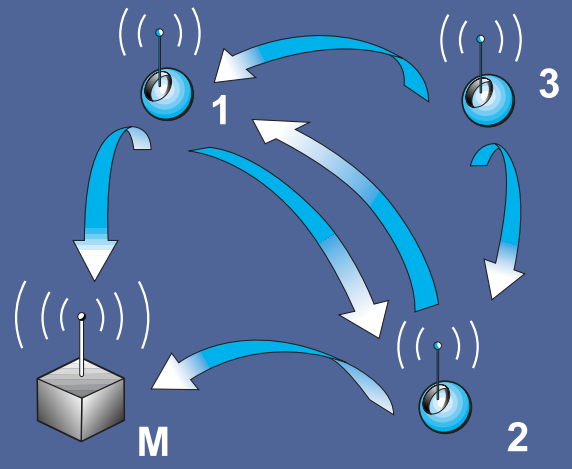
DATA HOPPING: LINEAR FORMATION

- Each node in contact with only its nearest neighbor
- Triple hop demonstrated



DATA HOPPING: DIAMOND FORMATION

- Multiple hopping paths to prime node
- Multiple paths demonstrates fault tolerance of sensor web
- Redundant data eliminated dynamically



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SENSOR WEB STATUS

Today:

- RF communication
- Error detection
- Simple data hopping
- Basic power management
- Basic sensors
- Breadboard components

Tomorrow:

- Error correction
- Handshaking data hopping
- Pod location/Web self-organization
- Field-qualified pods (moisture, radiation, etc.)
- Local energy harvesting
- Tighter internal node integration (system on a chip)
- Macroscopic data management (power consumption, sensor awareness, etc.)
- Field data for science community

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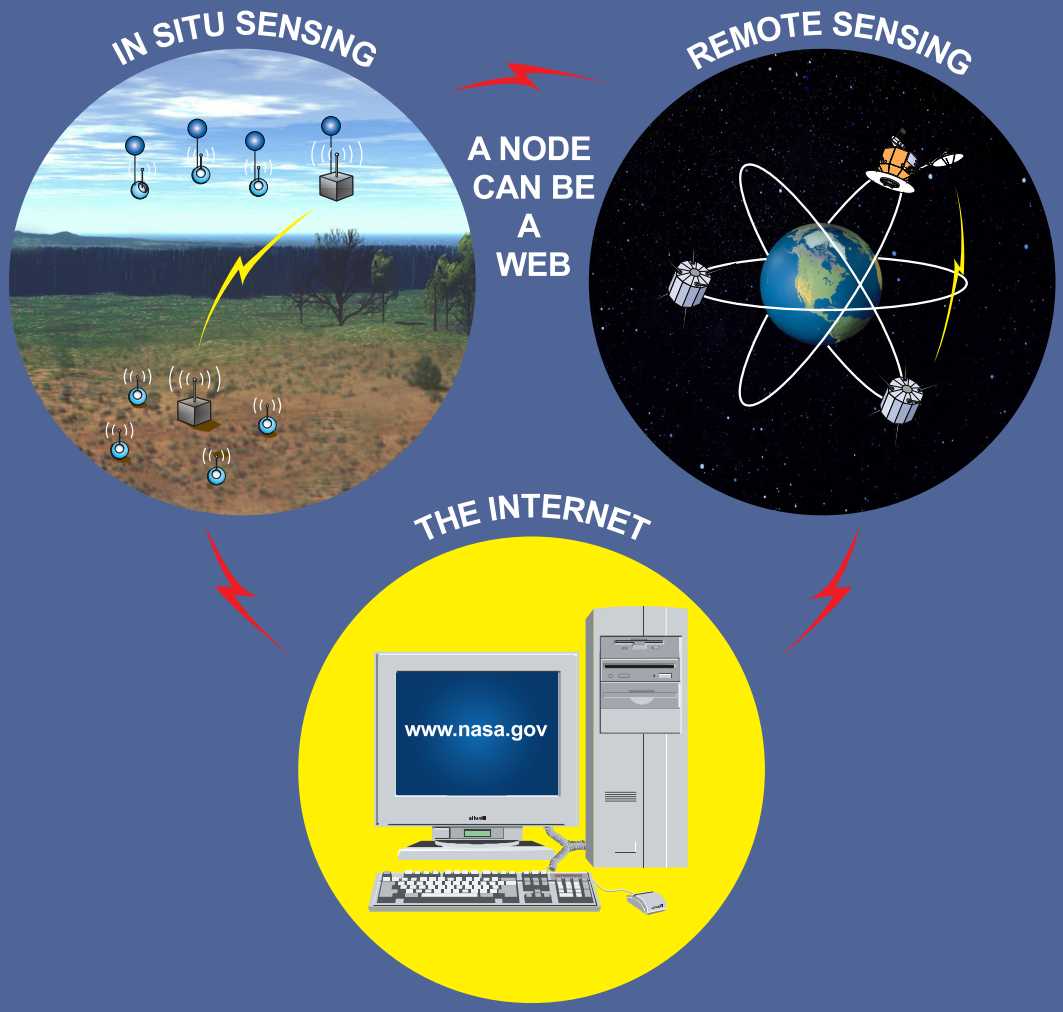
THE INTERWEB

A GLOBAL VIRTUAL PRESENCE



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